Japan's Energy Strategy

– Carbon Neutrality & Energy Security –

July 4, 2023

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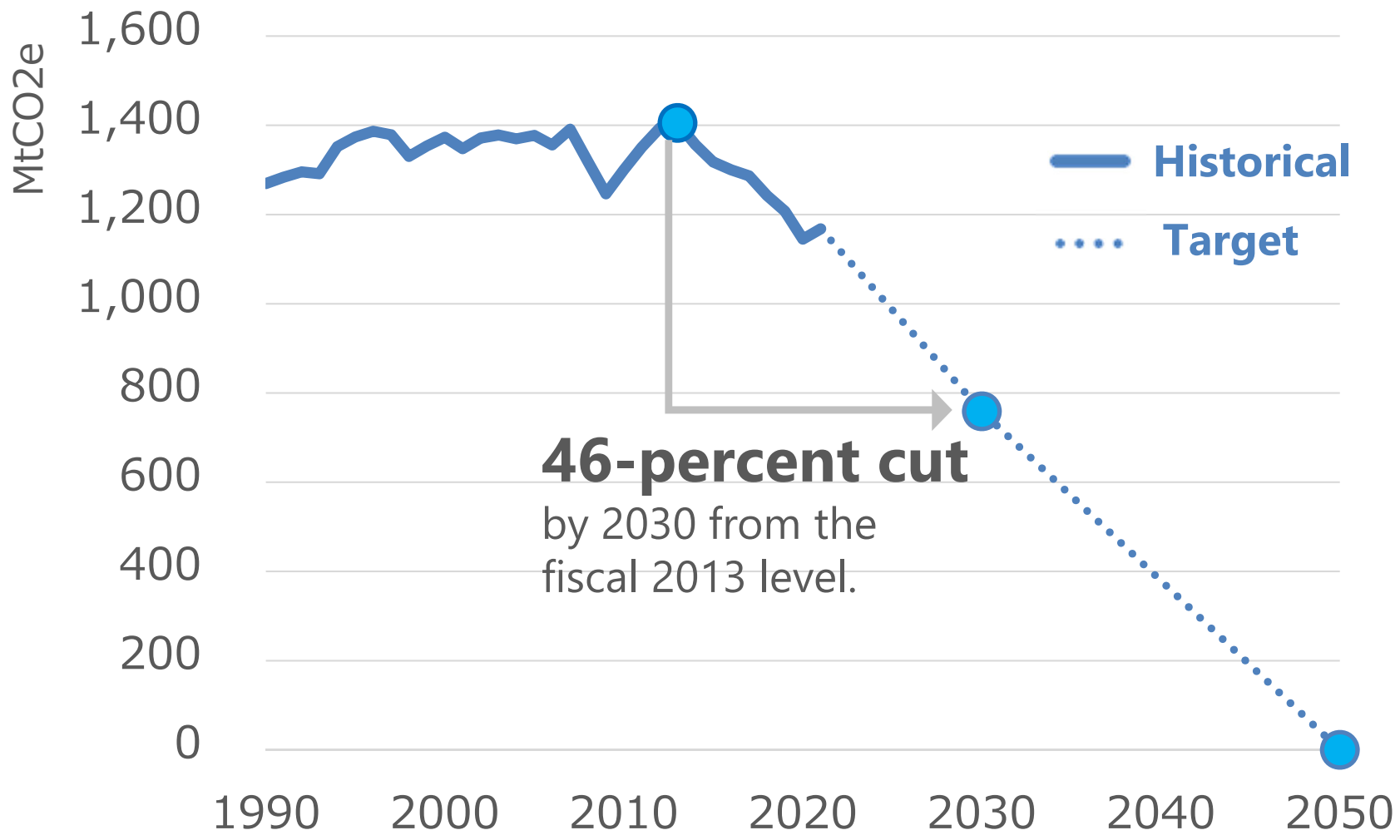
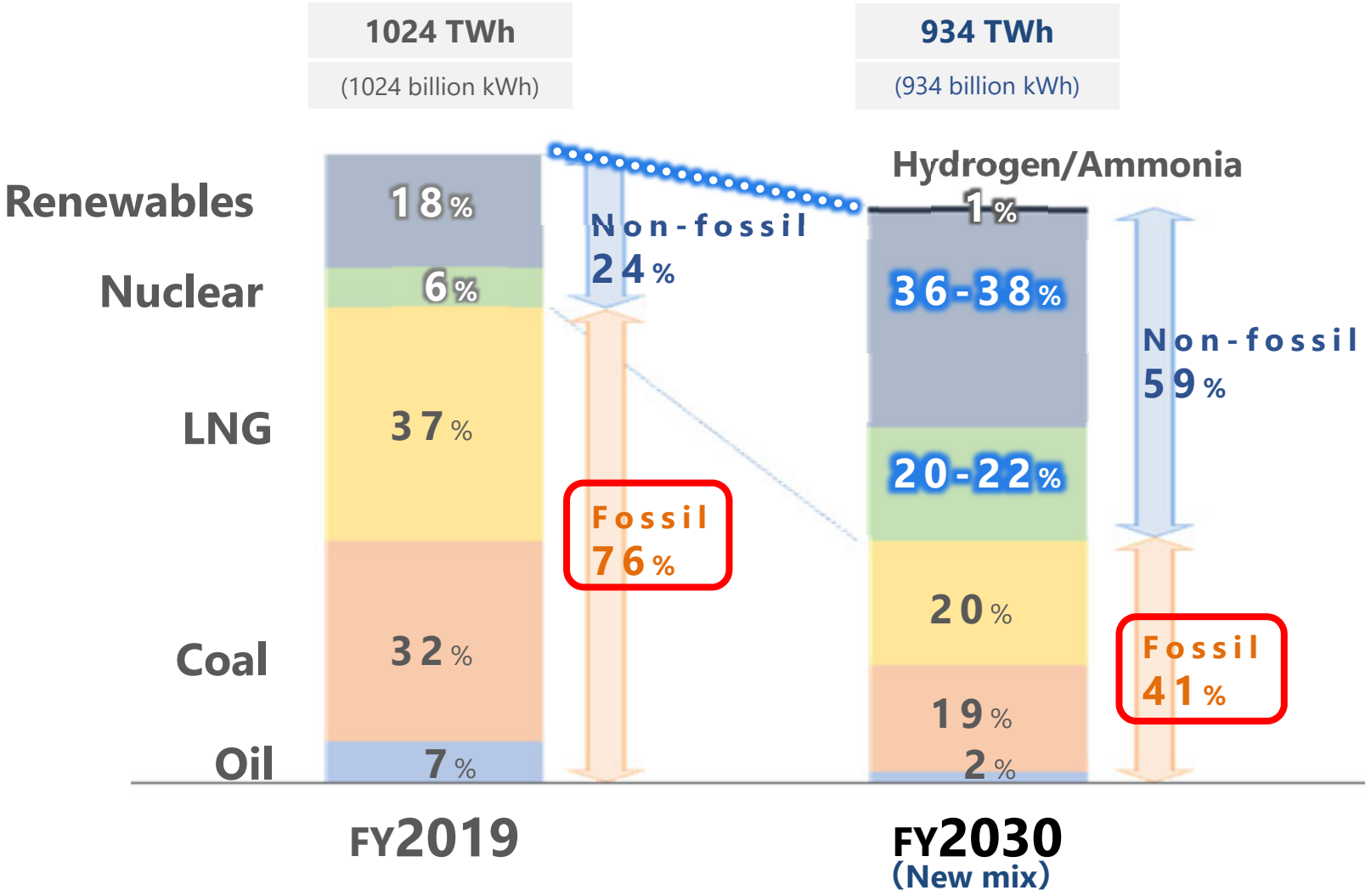
Achieving Net Zero GHG Emissions by 2050 in Japan



Current power generation structure vs. new energy mix

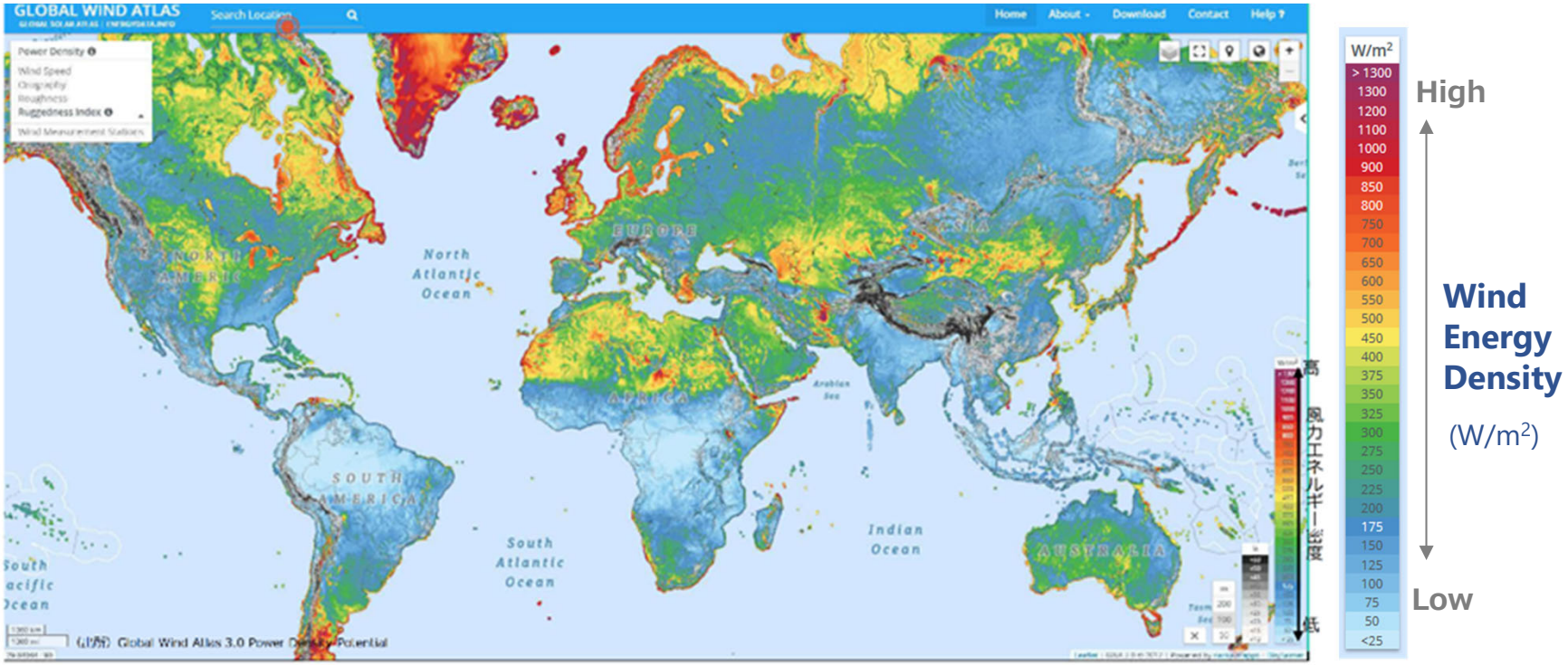


Source: Agency for Natural Resources and Energy "Outlook for energy supply and demand in FY2030（Reference material）」p.70, September 3rd, 2021.

Wind power potential

The **Asia-Pacific region** has lower wind speeds than **Europe**, except for some coastal areas.

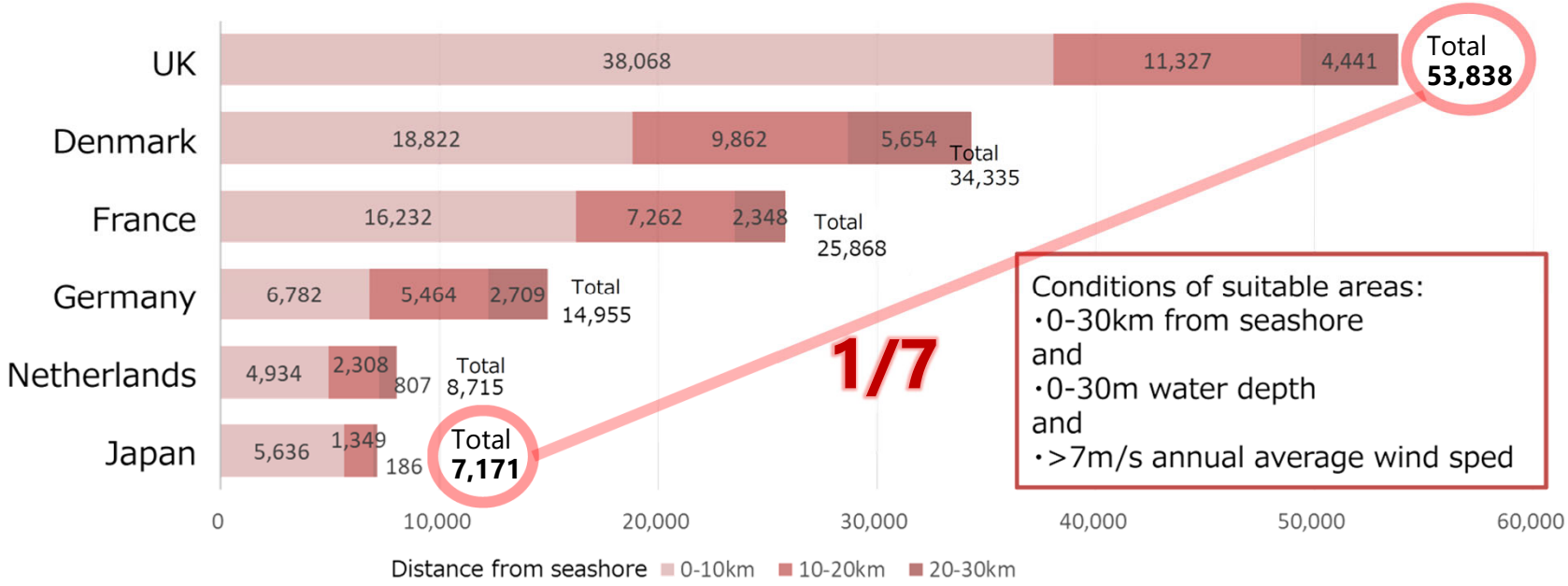
Moreover, it is **difficult to obtain stable wind energy** throughout the year due to the influence of typhoons.



Source: Trade Promotion Division, Trade and Economic Cooperation Bureau, METI,
"- Energy・Electricity -", The First Round-Table Panel for the Post 2020 Infrastructure Systems Export Strategy on April 24, 2020.

Fixed Offshore Wind Farm Potential in Japan is Limited

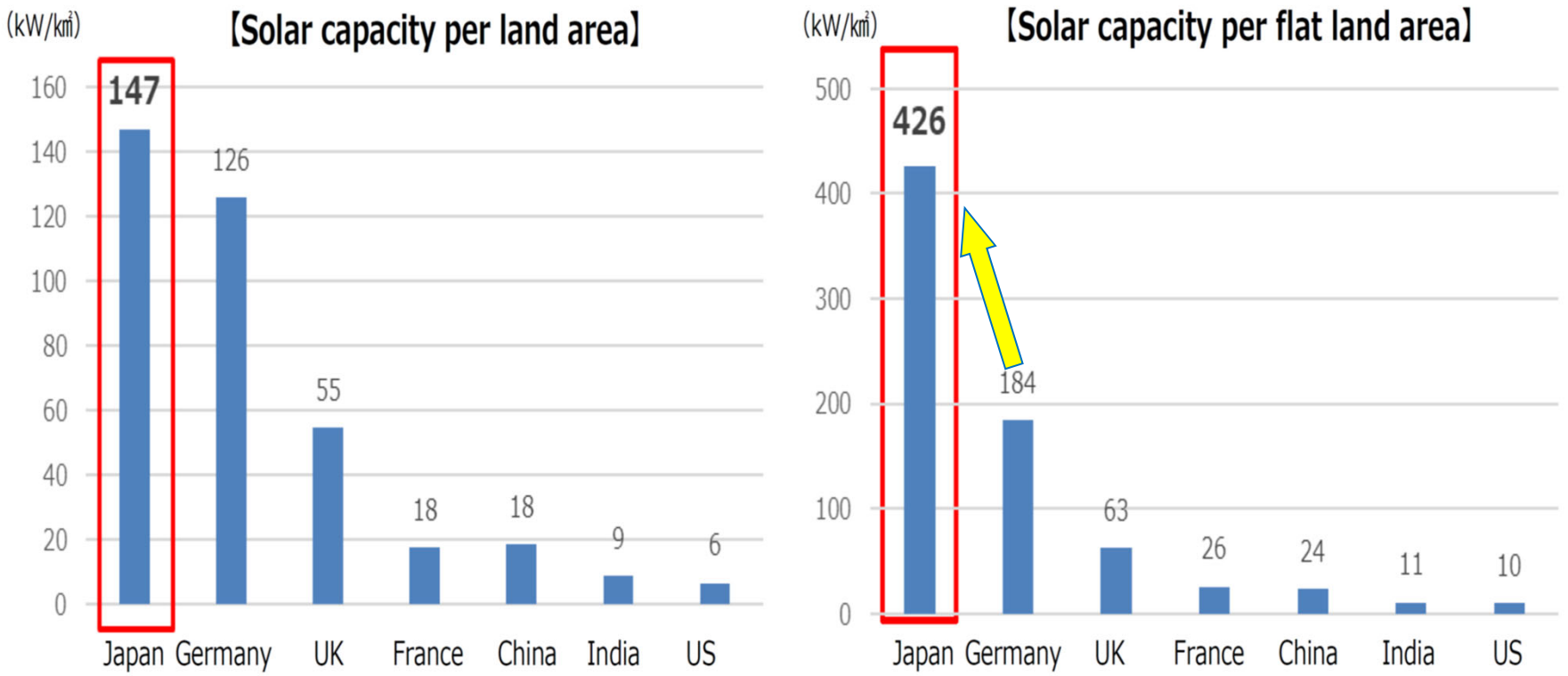
- Suitable areas for fixed offshore wind farm of Japan is less than **1/7 of UK**, and about 1/5 of Denmark.
  (UK: 53,838 ㎢ , Denmark 34,335 ㎢ , Japan: 7,171 ㎢)
- **Electricity demand of UK and Denmark is 1/3 and 1/30 of Japan.**



Source）"Fixed offshore wind introduction guidebook, NEDO, 2018"

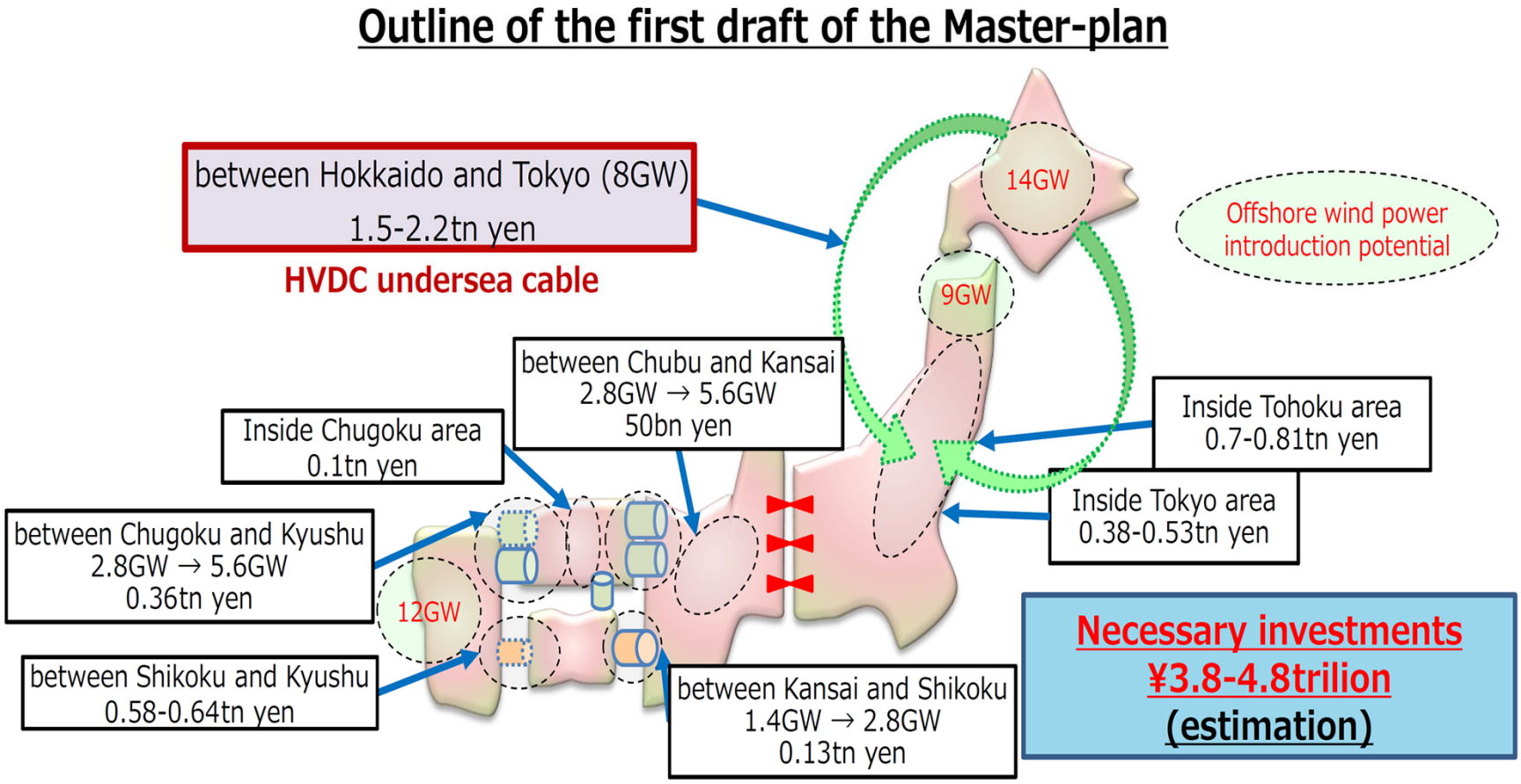
Expanding Installation of Solar is Challenging in Japan

- **Japan's installed capacity of PV per land area is the largest among major countries.** The capacity per flat area is **twice as large as that of Germany.**



Upgrading grids and their connection is under planning

- **The main grid systems** including regional interconnection lines, etc. will be **upgraded by the master plan.**

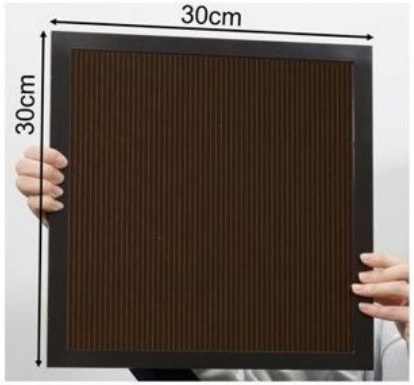


Next-generation solar PV : Perovskite solar cell

- Includes a perovskite (calcium titanate)-structured compound, most commonly a hybrid organic-inorganic material
- Developed in Japan
- Conversion efficiency doubled in 7 years (2014→2021)
- Lightweight, flexible and printable (applicable to various buildings)

Perovskite solar cell module

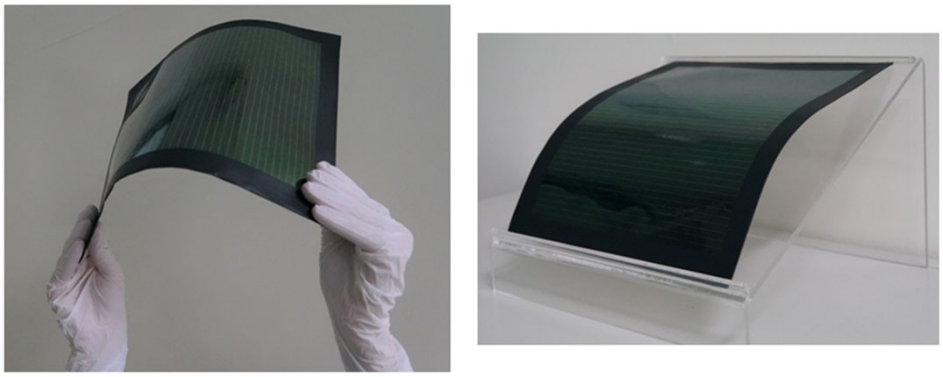
(804cm², conversion efficiency: 17.9%)



Source: Panasonic Corporation website

Film-based perovskite photovoltaic module

(703cm², conversion efficiency: 16.6%)

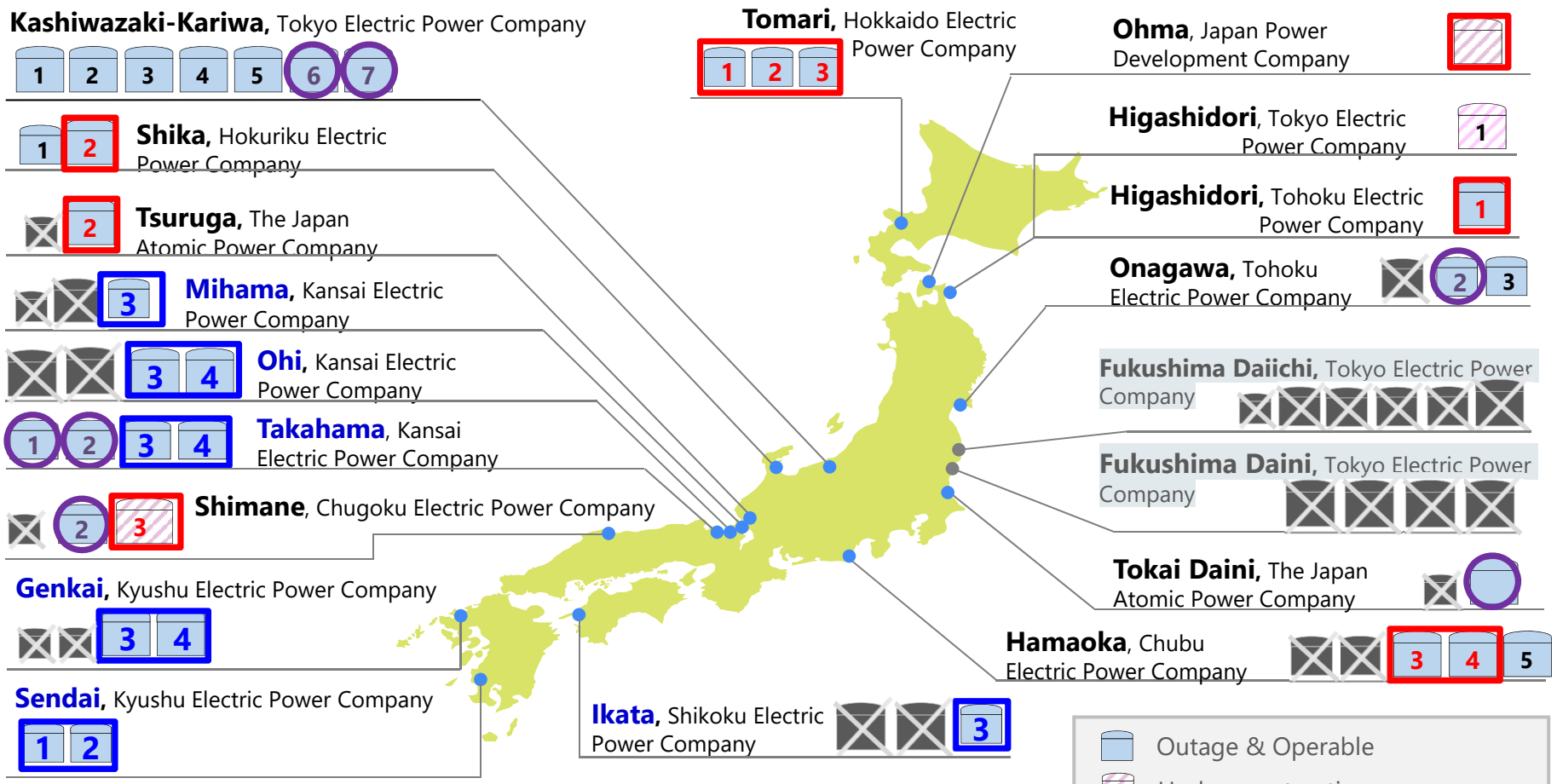


Source: Toshiba Corporation press release

Nuclear Power Plants in Japan

(As of May 26, 2023)

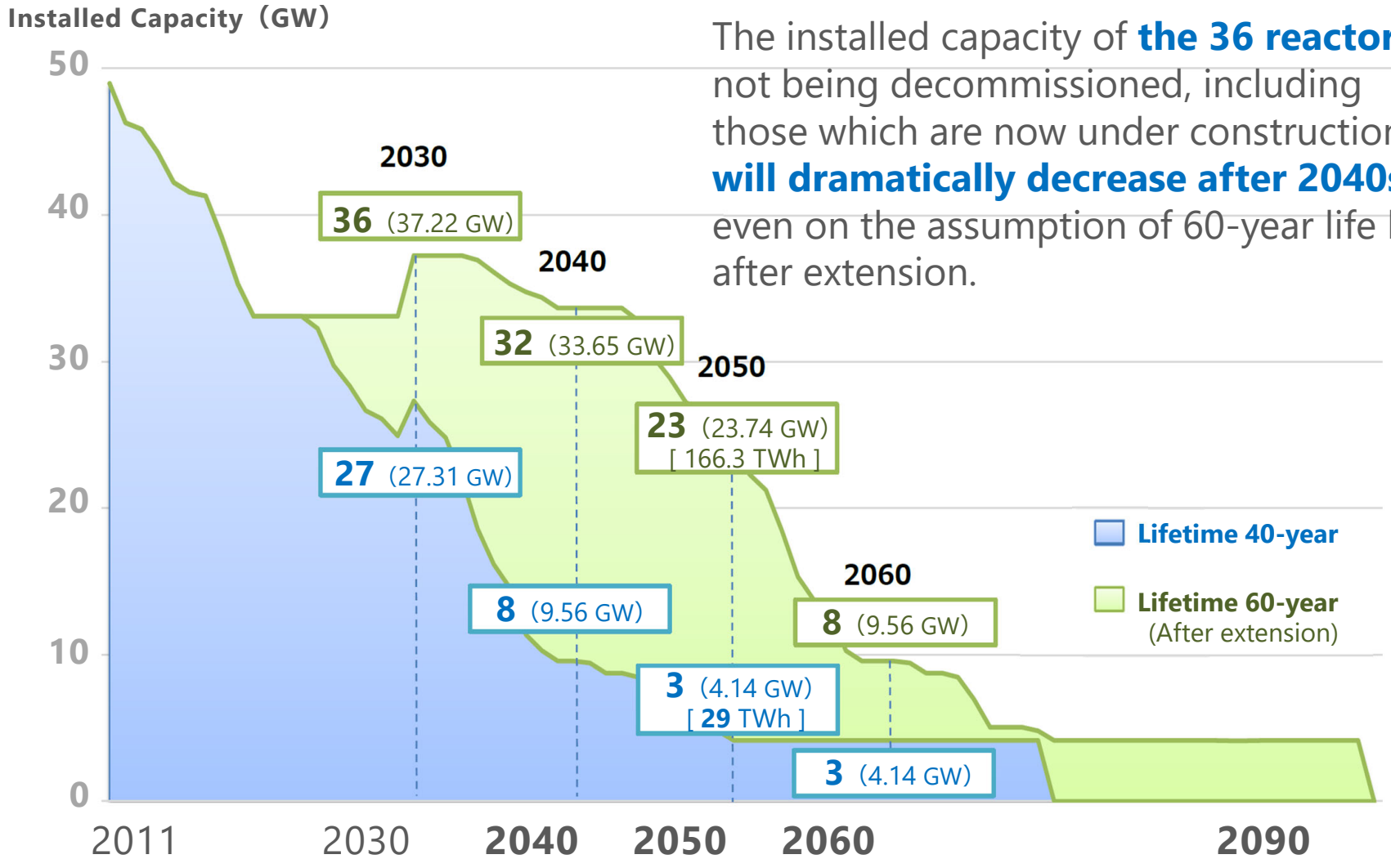
Restarted	Passed review	Under review by NRA	Not applied for review	To be decommissioned
10	7	10	9	24



Source: Compiled by IEEJ, based on "Current status of nuclear power plants" The Agency for Natural Resource and Energy (ANRE), May 26th, 2023

Operation outlook of Japan's nuclear reactors

(Lifetime of 40 years/ Lifetime of 60 years)



The installed capacity of **the 36 reactors** not being decommissioned, including those which are now under construction, **will dramatically decrease after 2040s** even on the assumption of 60-year life limit after extension.

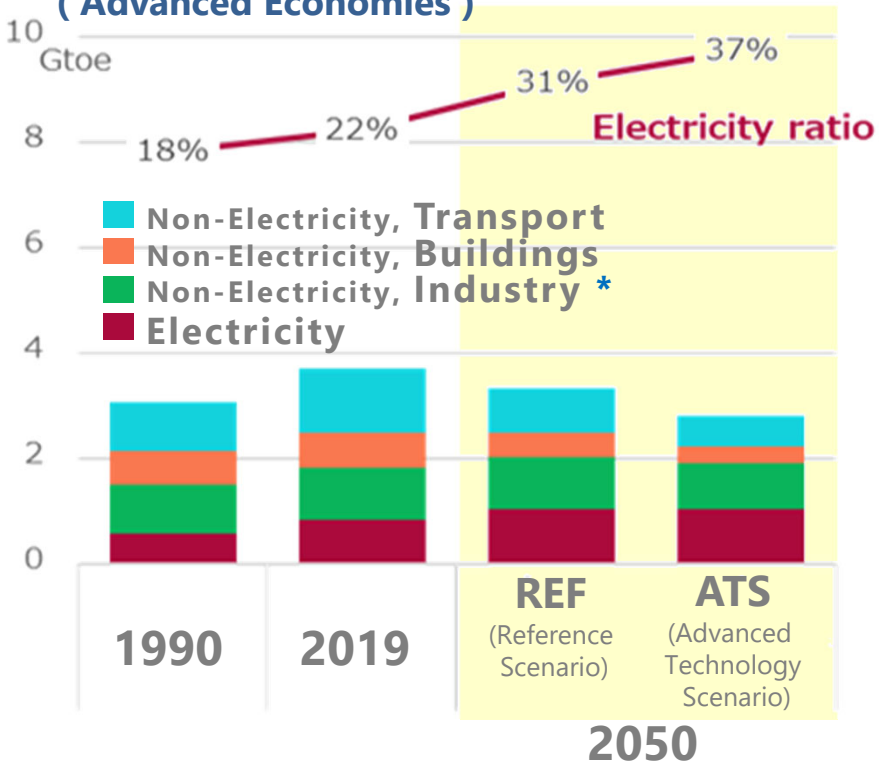
Source: "Addressing Japan's challenges for its nuclear energy policy" (P36), Feb 25th, 2021
Nuclear Energy Subcommittee, Electricity and Gas Industry Committee, Advisory Committee for Natural Resources and Energy, Agency for Natural Resources and Energy (ANRE)
https://www.meti.go.jp/shingikai/enecho/denryoku_gas/genshiryoku/pdf/021_03_00.pdf * Written in Japanese

Non-power sectors : Difficult to Decarbonize

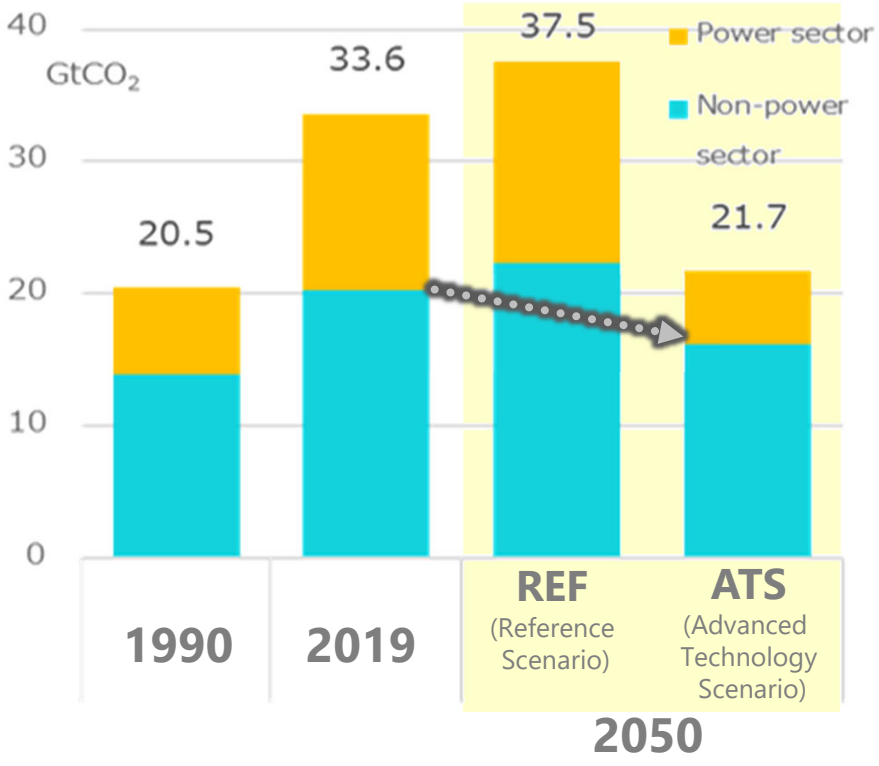
- Power demand is certain to grow but electricity ratio will be under 40%
- Decarbonization of non-power generation sector is difficult

Final Energy Consumption

(Advanced Economies)



Energy-related CO_2 emissions



* **Industry** includes agriculture, forestry and fisheries and non-energy sector.

Source: IEEJ, October 2021

Hydrogen's roles in non-power sectors

- **Hydrogen** will play a critical role to decarbonize non-power sectors.

Sector	Hydrogen utilization
Steel	**Hydrogen** direct reduction; **Hydrogen**-based fuel (such as synthetic methane)
Chemical	**Hydrogen**-based feedstock; **Hydrogen**-based fuel (such as synthetic methane)
Aviation	**Hydrogen**-based fuel (Sustainable Aviation Fuel: **SAF**)
Maritime Transportation	Clean ammonia or clean methanol produced from **hydrogen**
Land transportation	Fuel-cell vehicles (**FCV**); FC Truck/Bus; E-fuel based on Fischer-Tropsch synthesis with clean **hydrogen**

Transportation is the key to realize hydrogen economy

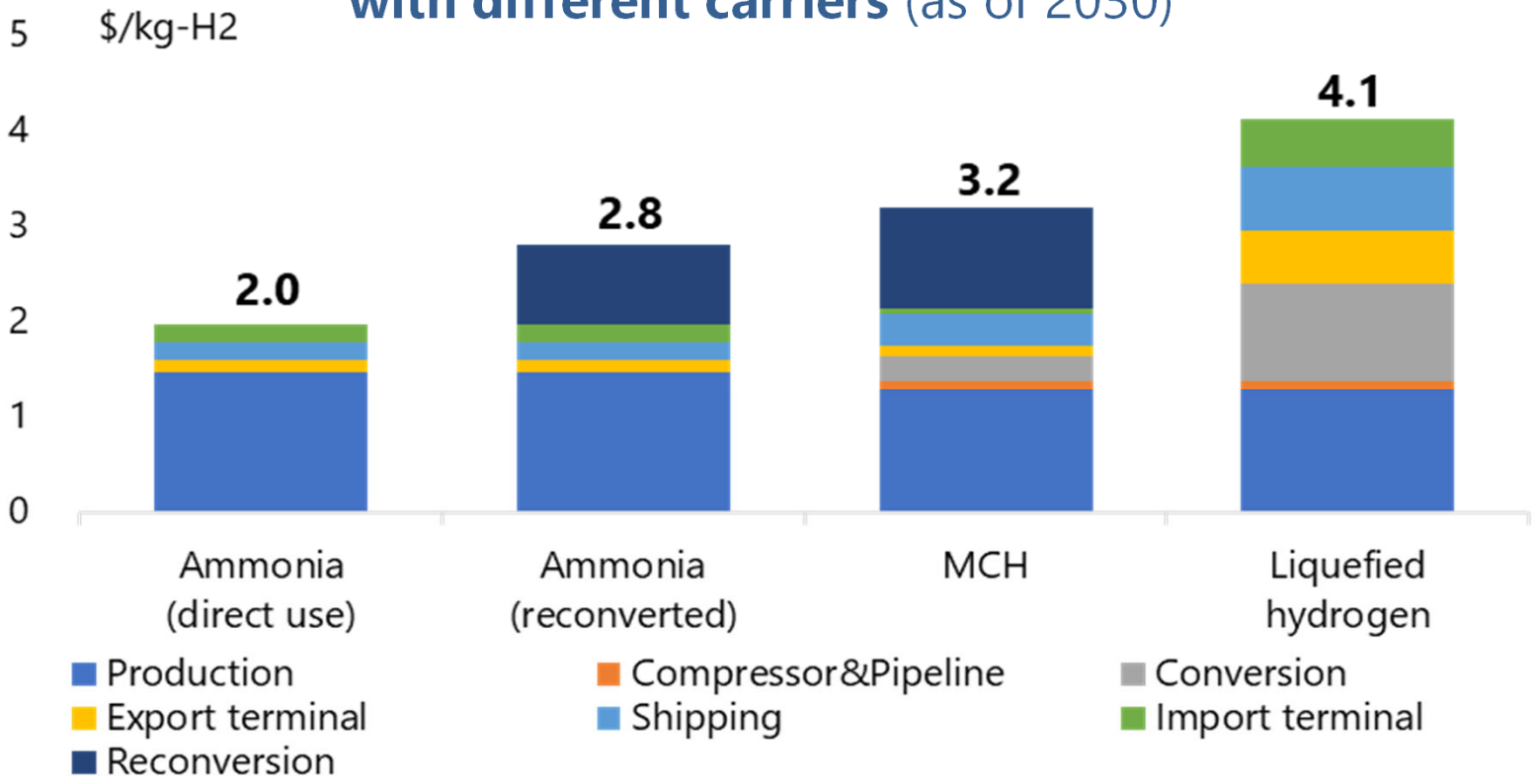
■ Each transportation means (carrier) has particular advantages and disadvantages.

Fuel	Pros	Cons
Liquefied Hydrogen	No purification or cracking facility is required.	Difficult to transport (liquefied at **-253°C**) High cost to liquefy and transport
Methylcyclohexane (MCH)	Easy to transport (**liquid** under the ambient condition)	High cost for cracking
Ammonia	Easy to transport (liquefied at **-33°C**) Direct utilization as fuel	Toxic, NOx emissions

Hydrogen and Ammonia

- Ammonia will be the most competitive carrier to transport hydrogen for long distance as of 2030.

Estimated supply cost of hydrogen from Saudi Arabia to Japan with different carriers (as of 2030)



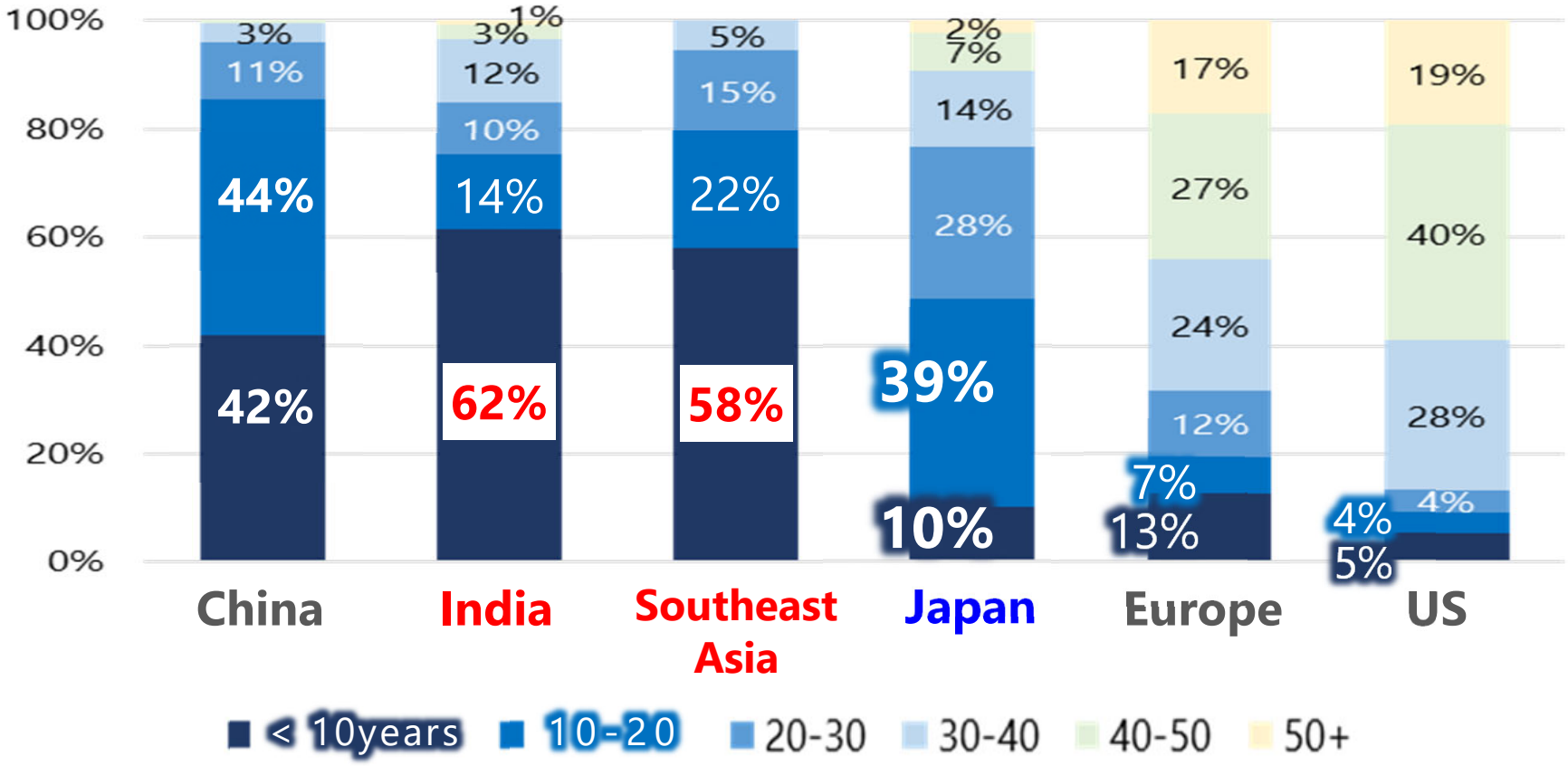
MCH: Methylcyclohexane

Source: IEEJ Analysis, 2021

Young fleet of coal power plants in Asia

- Asia's electricity demand will keep growing, and the average age of **its coal power fleet is still young**.

Shares of coal-fired power capacity by age (as of 2018)



GX Roadmap

1. 10 year plan for the Green Transformation

- 150 trillion-yen investment in energy transition
- 20 trillion-yen government spending financed by GX bonds

2. Carbon Pricing

3. Renewable Energies

- Long distance transmission lines

4. Hydrogen/Ammonia

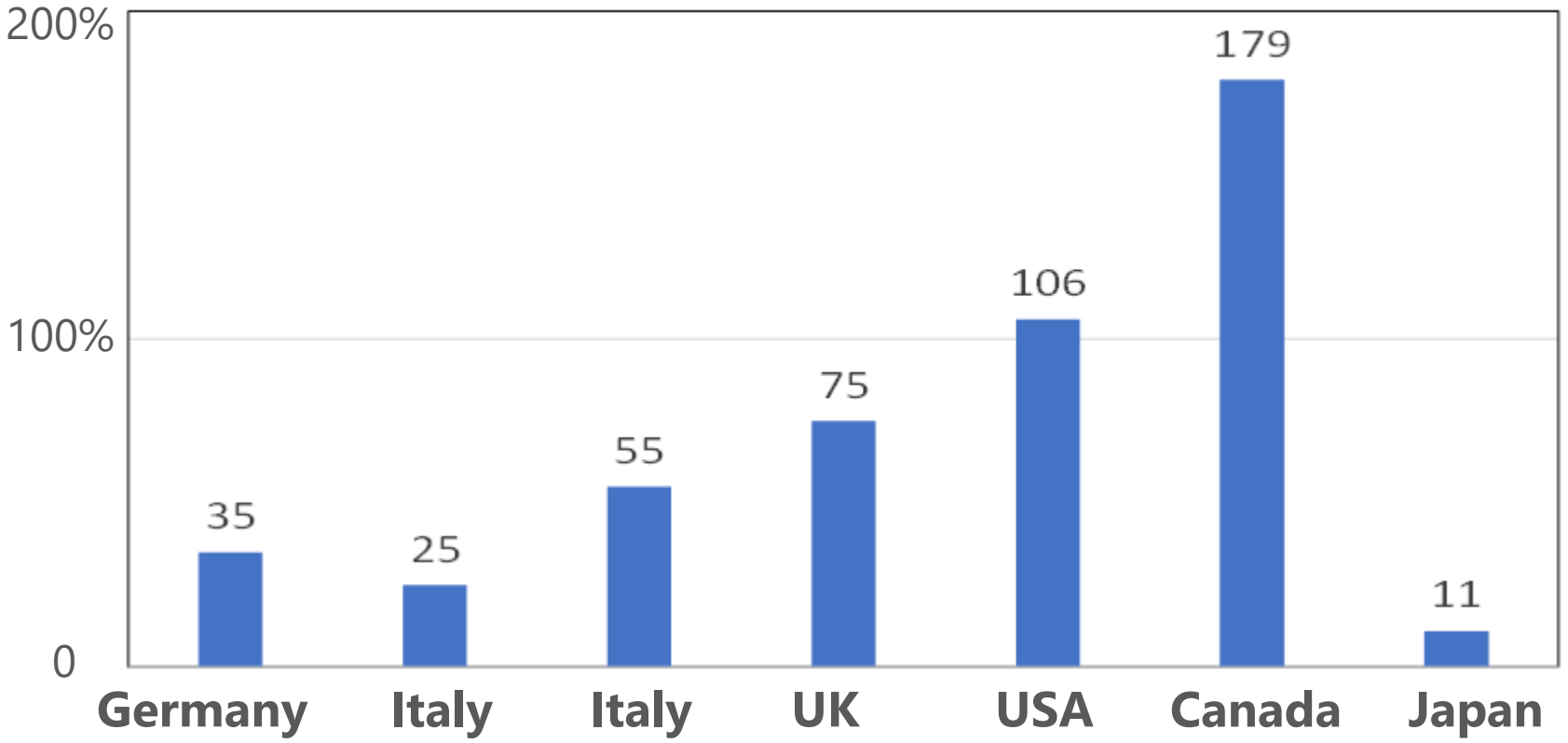
- Framework to offset cost disadvantage

5. Nuclear Power

- Restarting nuclear reactors
- Extending operation lives
- Replacement of old nuclear reactors

Comparison of Primary Energy Self-Sufficiency Ratios of Major Countries（2020）

The USA and Canada are net exporters. UK and France are over 50%. Germany and Italy are low, and Japan is extremely low.

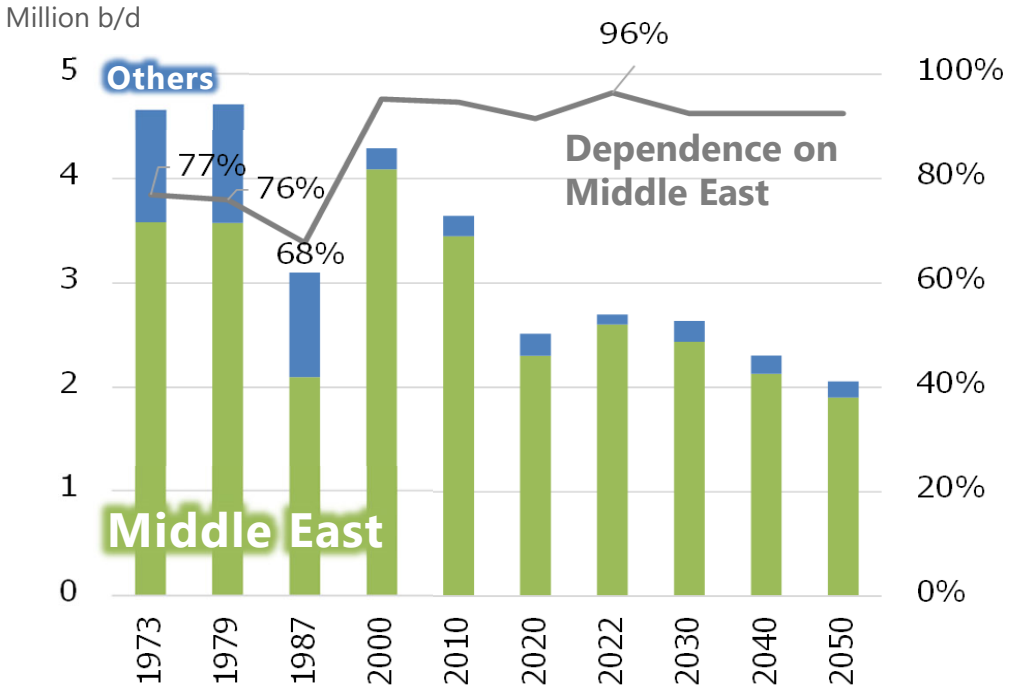


Source: Compiled by IEEJ from various sources

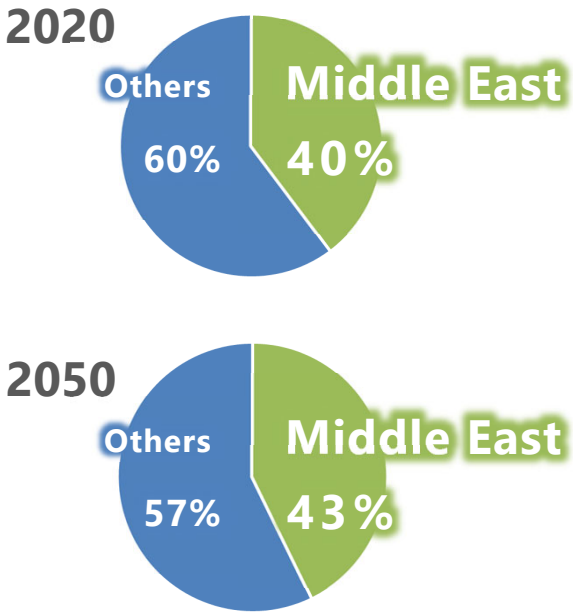
Middle East weight in crude oil supply

- Japan's dependence on Middle East crude oil is expected to remain at an extremely high level.
- On a global level, dependence on the Middle East is also expected to increase.

Trends in Japan's crude oil imports and dependence on the Middle East



World Crude Oil Exports and Middle East Share

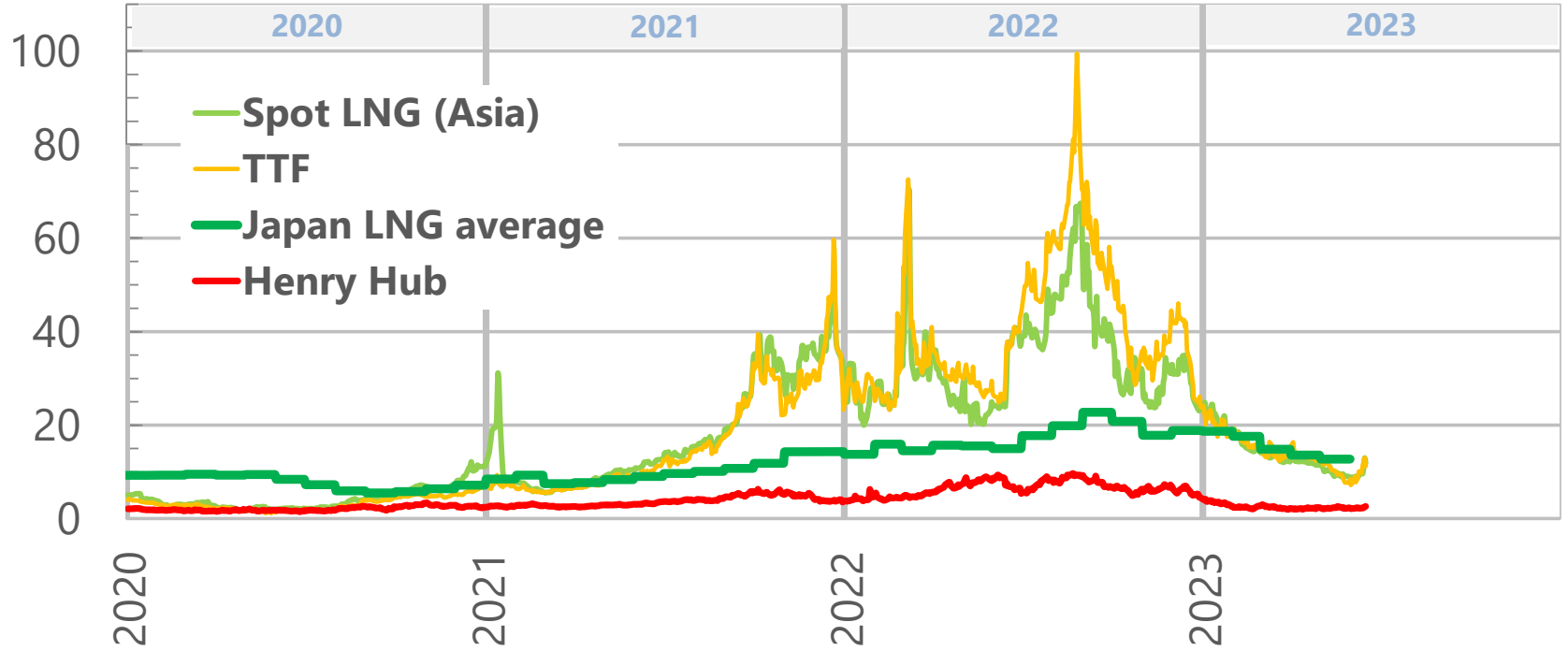


Source: Compiled by IEEJ from various sources

Natural Gas and LNG Prices by Region

European gas prices have declined since mid-December 2022 after hitting record highs in summer 2022
(Against the backdrop of reduced consumption and high storage levels caused by mild winters and stalled economic activities in Europe)

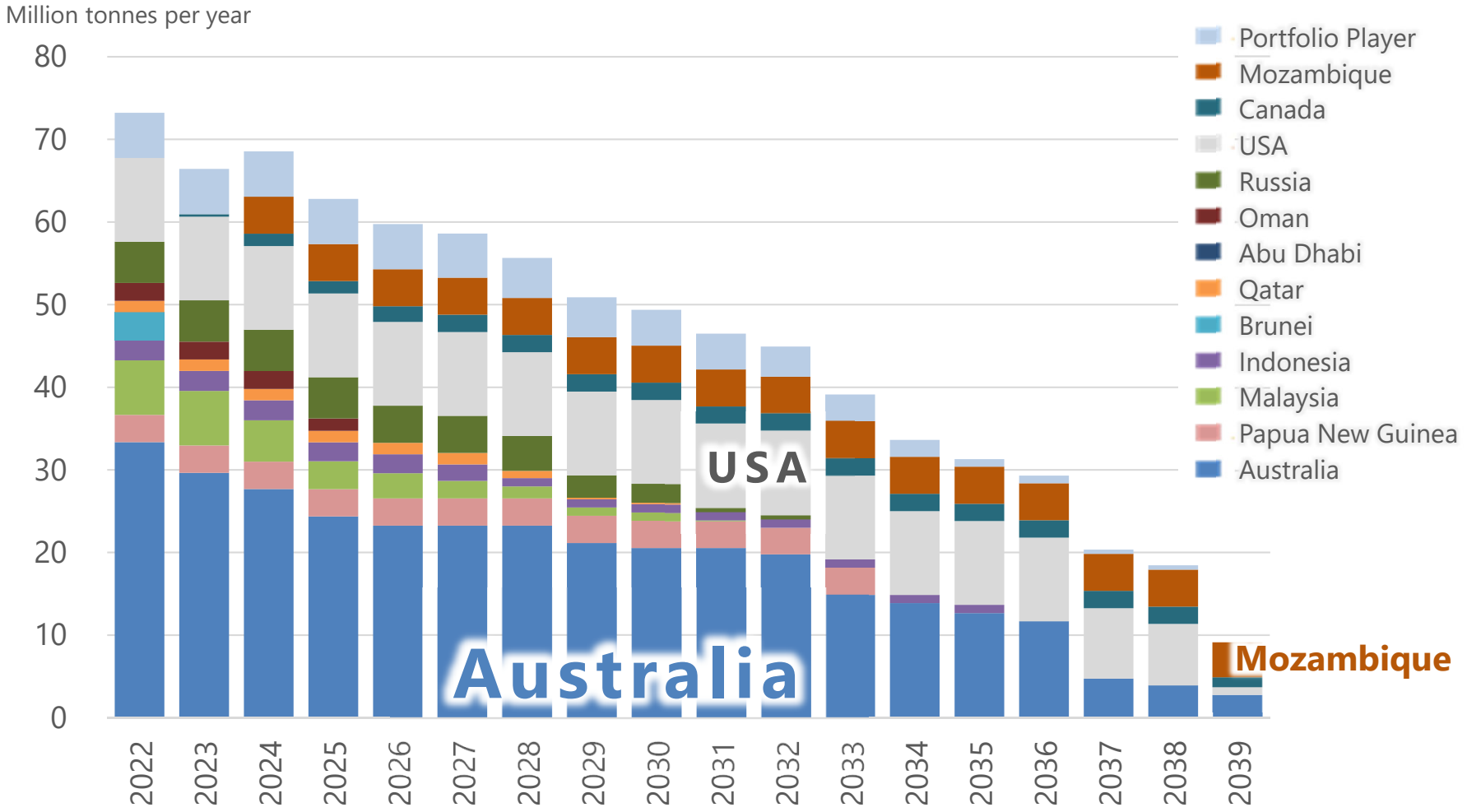
Units: USD/million Btu



Source: Compiled by IEEJ from various sources

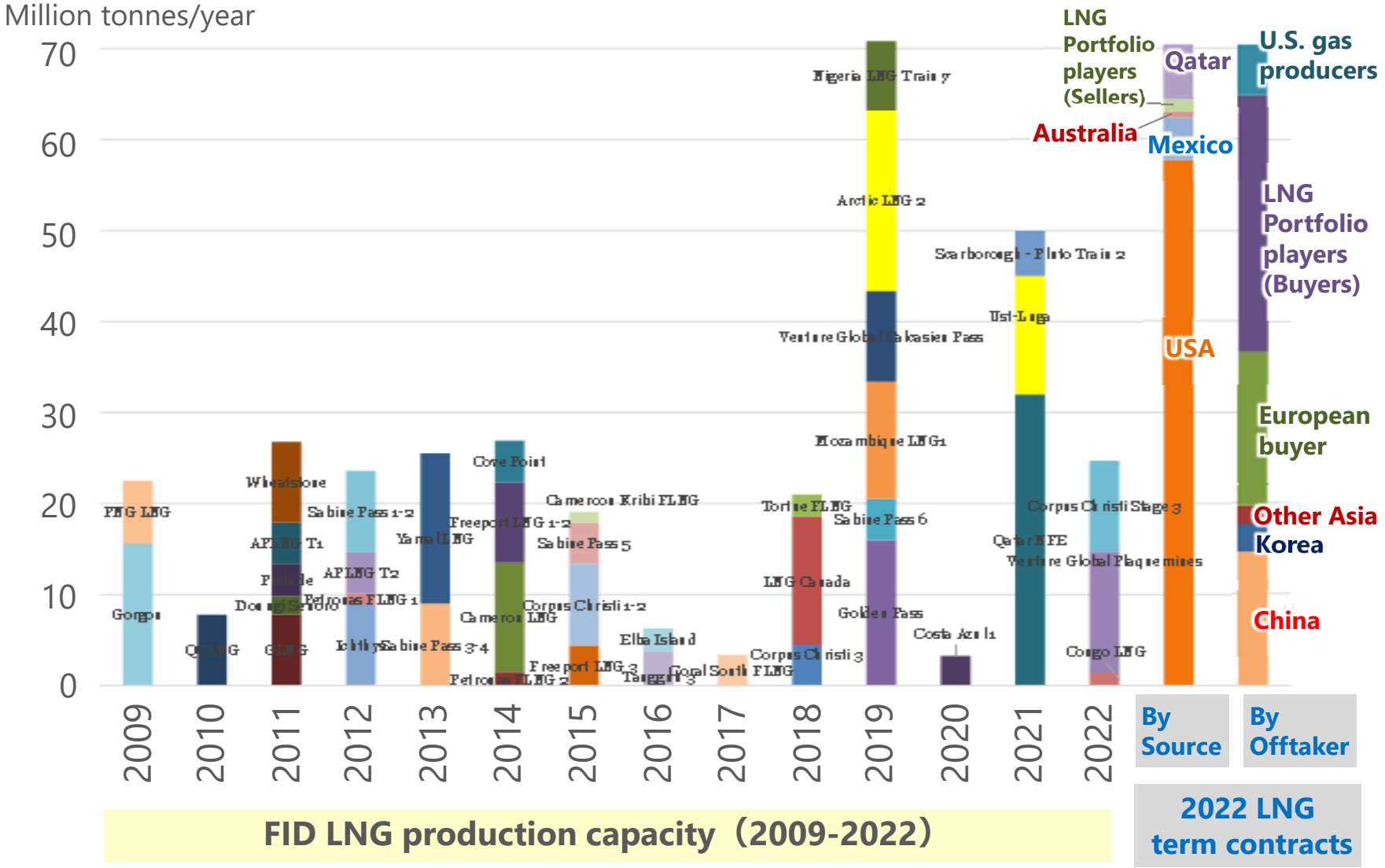
Challenges to Phase Out Russian LNG

LNG Volumes Secured by Japanese Companies under Term Contracts



Source: Compiled by IEEJ from various sources (October 2022)

Progress Expected in LNG Production Investment



FID LNG production capacity（2009-2022）

Source: Compiled by IEEJ from various sources (December 2022)

G7 Summit : Climate/Energy/Environment

1. Common Goal, Various Pathways

- Various paths to reduce CO_2 emissions by 50% from vehicles by 2035
- Various paths to predominantly decarbonize power sector by 2035
- Carbon intensity to define clean hydrogen
- Carbon management including CCS & CCU (e-methane, e-fuel)
- "Transition Finance" & "Avoided Emissions"
- Cross border measures recognizing various means to promote energy transition + respecting WTO rules & principles

2. Energy Security

- Resilience of supply chains for critical minerals
- Role of investment in gas sector

3. Global South

- Energy Access?
- Energy Affordability?

S+3E

The basic principle of **Japan's energy policy** for the future, known as **3E+S**, has been established to cope with various challenges.

Keeping in mind that **Safety always comes first**, the principle is to simultaneously achieve **Energy Security**, **Economic Efficiency** and **Environment**.